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REPORT OF THE TURNER VALLEY GAS CONSERVATION BOARD.

Introduction

Prior to the passing of the Turner Valley Gas Conservation Act, efforts had been made by the Government to bring about some form of unit operation in the Turner Valley Field with the object of curtailing the wastage of natural gas, and the services of Mr. F. P. Fisher, an engineer of high standing, had been retained for that purpose. A Technical Sub-Committee of the Oil and Gas Advisory Committee, consisting of three members and of which Mr. Fisher was Chairman, evolved a plan of voluntary pooling of the properties in the field and it was then hoped that it would be possible to persuade the various interests concerned to adopt that plan and thus eliminate not only the further wastage of gas but also a large part of the operating costs of the various producing companies. It was found, however, that the parties interested could not be brought into any agreement and after a final and fruitless conference of the operators held in Calgary during the last days of the Session of the Legislature, the Turner Valley Gas Conservation Act was passed.

The Turner Valley Gas Conservation Act provided for the appointment by the Lieutenant Governor in Council of a Board consisting of not more than three persons, the general object of such Board being the effecting of conservation of gas in the area set out in the Act and for the further purpose of endeavouring to bring about the unified operation of the wells in the field by means of pooling or otherwise.

Forthwith after the appointment, the Board was required to proceed to reduce the gas production in the field to not more than 200 million cubic feet daily. Thereafter, the Board was required to proceed with a series of tests of the wells in the field, the nature of these tests to be determined by the Board, for the purpose of determining the capacity of each well both in regard to gas and naphtha production, the measured value of each well and of any gas or oil rights in any area and the total gas reserves. The Board was also required to determine the amount of gas necessary to meet the market demands and other requirements and to also determine efficient methods of effecting gas conservation.

Organization and activities of the Board.

In pursuance of the above Act and by Order in Council No. 362/32 and dated April 23rd, 1932, a Board was constituted the persons appointed thereto being Dr. R.C. Wallace, President of the Unitersity of Alberta, A. A. Carpenter, Chairman of the Board of Public Utility Commissioners and John McLeish, Director of Mines, Ottawa.

A meeting of the Board was held on April 28th for the purposes of organization, at which meeting A.A. Carpenter was appointed Chairman. Offices were secured in the old Telephone Building in Calgary and the setting up of the necessary staff for carrying out the work set out in the Act was proceeded with. Appointments to the staff were made as follows: Field Staff: C.W.Dingman, G.R.Elliott, J.O.G. Sanderson, R.V. Johnson, F. W. Shelton. Office Staff: D.S.Pasternack, Statis-

tician, Miss P. Darby, Stenographer. Arrangements were made with the firm of Harvey and Morrison, Chartered Accountants, for the services to the Board of Mr. J.S. Simpson for the purposes of accounting.

The services of Mr. F.P. Fisher, the Engineer employed by the Government in the endeavour to work out a voluntary pooling of the Field, were retained by the Board for a period, for the purpose of organizing the tests to be carried out in the field. On the completion of their organization, Mr. C.V. Dingman was placed in charge of the field staff. The members of the Board, however, were of the opinion that it was advisable, when these tests were got under way, to call in the services of an engineer of wide experience in gas production, operating and pooling problems, who had not had any previous connection with the field, for the purposes of consultation and advice. Accordingly, the Board, about the time of the inauguration of the tests, secured the services of Mr. Frank Mc.C. Brewster, of Bradford, Pennsylvania, who came to the Board with strong recommendations from both the Department of Mines at Ottawa and from the Head of the United States Bureau of Mines.

The question of the nature of the tests to be carried out on the various wells in the field had been discussed at the conference held by Doctor Wallace with the operators in Calgary, prior to the enactment of the conservation legislation and at a meeting of engineers representing the various companies, a formula of tests was there evolved. This formula, though it eventually appeared that it did not represent a unanimous agreement amongst the interested parties, might, in the Board's

opinion, be expected to yield the data, material for the determination of the various matters to be dealt with. Prior to the adoption of this formula, the Board notified the various operators in regard thereto and asked for their suggestions.

These tests involved the metering of all wells for a certain period, the taking of their closed pressures for a seventy-two hour period, the taking of a ten day naphtha test with the wells operating at two-thirds of the regional closed in pressure and a gas flow test taken at a pressure of 500 lbs.

There are approximately some ninety producing wells in the field, none of which were, or at the present time are, metered. It was considered impossible to cover with a meter test, the whole field at once but the Board purchased twelve meters and secured thirteen meters on a rental basis, thus putting at its disposal twenty-five meters.

Owing to this limited number of meters, it was found necessary to divide the field for test purposes into four areas, it being the intention that the tests should be made in these areas successively.

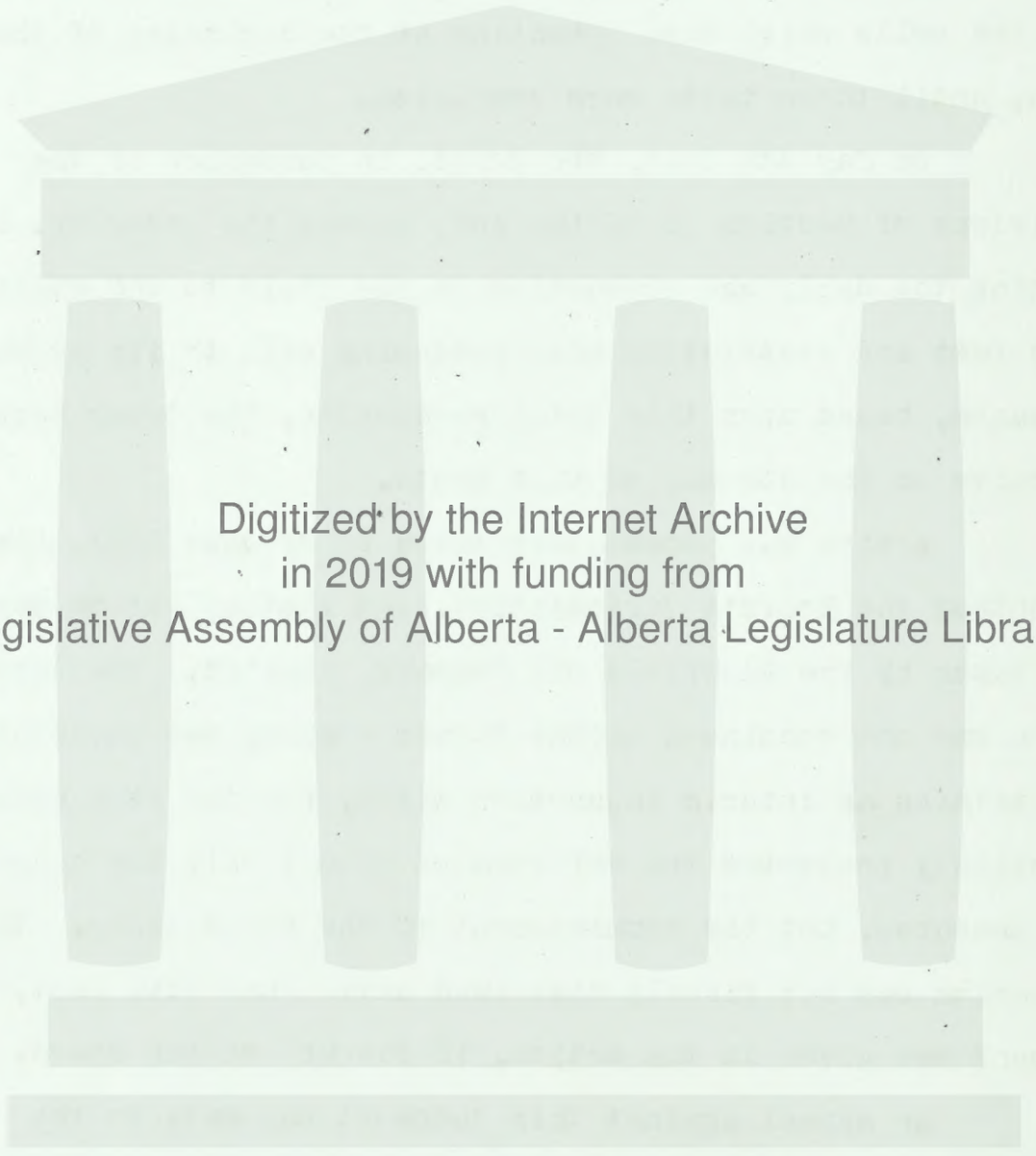
Provision was made in the Act that during the time the field tests were being carried on, two or more wells belonging to the same person or two or more wells belonging to different owners, if these owners should agree, might be operated as a unit, if the written consent of the Board were obtained. However, in order to obtain comparative data in the field tests, it was found advisable to maintain the flow continuously from the individual wells, as a pooling

of production of several wells through the operation of a less number thereof, would have the direct effect of disturbing the balance of underground pressures and thus invalidate the data from the comparative point of view. This objection was raised at the outset by a number of operators and it was decided that operators should maintain their production from the wells which were operating at the beginning of the tests, until those tests were completed.

On May 4th last, the Board, in pursuance of the provisions of Section 13 of the Act, issued its Order No. 1, limiting the daily gas production in the field to 200 million cubic feet and restricting each producing well to its prorated allowance, based upon this total production, the Order being effective on the 9th day of that month.

Action was immediately taken by Spooner Oils, Limited to contest the Board's jurisdiction, and similar action was also taken by the Richfield Oil Company, Limited. The latter action was not continued but the former company was successful in obtaining an interim injunction which, for the time being, effectively prevented the enforcement of not only the conservation measures, but the commencement of the field tests. This injunction was not finally dissolved until June 24th last, when judgment was given in the action, in favour of the Board.

An appeal against this judgment was made to the Appellate Division of the Supreme Court and came on for hearing in October last. The Appeal Court held that the main provisions of the Act were intra vires but that the provisions relating to the levying upon the operators for the expenses of the Board in carrying on its operations, were ultra vires. No levies, however, had been made under these provisions, so that



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no complications resulted from this finding.

The result of these injunction proceedings was that the tests in the first area could not be proceeded with until the early part of July last, and the completion of the tests in the last area was delayed until November 13th. At the close of the tests referred to, a twenty-four hour closed in pressure test over the whole field was taken but owing to weather conditions, was not completed until the last week in November.

Literal compliance with the terms of the Act in so far as the completion of the public inquiry and in so far as the submission of the Board's Report is concerned, has, as a consequence, been impossible. Apart from this, the field tests have taken considerably more time than originally estimated, while the time required for the assembling of the data obtained in these tests, was apparently not considered when drafting the Act.

The first Order was based upon the information available in the office of the Petroleum and Natural Gas Division of the Department of Lands and Mines. As none of the wells in the field were metered, an effort was made in this Order to translate the gas allowances into naphtha production so as to afford a ready method of measurement.

The only record of closed in pressures available at that time was that obtained by the Department of Lands and Mines in August, 1931, as a result of a twenty-four hour closed pressure test. In order to correct as soon as possible any inequalities occurring in its first Order, the Board took another twenty-four hour closed pressure test in the early part of last July. A new Order, based upon information obtained in this test, was issued on August 4th last and in this Order it was found

advisable to abandon the method of measurement by means of naphtha production and adopt a simple gas quota. From time to time this Order was varied as a result of the data that became available from the tests in the various areas. It was also necessary as each area came under test, to adjust the quotas allowed for the various wells outside the particular test area and Orders were issued from time to time for this purpose. At the close of the tests, the Board issued a new Order, numbered 20, based on the data secured in these tests, this Order being still in effect.

With the wells unmetered, it has been found extremely difficult to ensure absolute observance of the Board's Orders for restriction. During the test periods, the Board's field staff was fully occupied and between these tests the recording of the data derived therefrom left little time available for the policing of the field. As far as possible, this was done but no efficient policing of the field can be accomplished unless meters are placed on all producing wells. Once this is done, efficient records can be kept of gas production at all times, at comparatively small cost.

Although the field tests were far from complete, the Board deemed it advisable to fix the 30th day of September for the opening of the Public Inquiry provided for by Section 18 of the Act, but the attention of the interested parties was called to the fact of the incompletion of these tests and the obvious necessity of an enlargement of the hearing. After further adjournments, the date of the Public Inquiry was finally fixed for the 9th of January of this year, but owing to certain injunction proceedings that had been initiated, the commencement of the actual hearing was delayed until the afternoon of the following day.

Prior to the date mentioned, the Board had sent out to all operators, drafts of two alternative plans of conservation which they were asked to consider in order to be in a position to discuss and criticize them at the hearing. When the Inquiry proceeded, the Board invited the fullest discussion of these plans and also of the other matters material to the questions involved.

A transcript of the proceedings and of the evidence submitted at the Public Inquiry is being transmitted along with this Report.

General conditions in the Turner Valley Field.

Before dealing with the question of conservation in any form whatever, it may be advisable to refer to the conditions now existing in the Turner Valley Field. A large portion of the field, that which has been closely drilled and where the wells have been operating for a considerable period of time, shows very marked signs of depletion. On the other hand, there is an area in the Northern end where the pressures are still high, while in the Southern end of the field the wells are comparatively recently drilled and show high pressures and large naphtha production.

It must be borne in mind that, generally speaking, the wells in Turner Valley were not drilled with any idea of obtaining revenue from gas production. They were drilled with the sole object of obtaining naphtha production and it is doubtful whether, at least until recently, sufficient thought was given to the fact that the gas energy supplies the nec-

essary power to bring any free naphtha into the hole and lift it to the surface, or to the further fact of relative efficiencies of naphtha production at varying gas back pressures. Apart from the Royalite Company, which has a monopoly for the supplying of gas to the Canadian Western Natural Gas, Light, Heat and Power Company, Limited, gas production was considered a necessary and possibly unwelcome accompaniment of naphtha production.

In the depleted area referred to, there is a considerable number of wells where the pressures have fallen to the point where only a very small naphtha production is obtained. The gas oil ratios in these wells have steadily grown worse, in many cases running as high as 400,000 cubic feet or more to a barrel of naphtha, while in a few cases, the gas oil ratios are so high that the wells should not be treated as other than dry gas wells. Many of these wells, indeed, have reached the stage when their operation as commercial propositions can only be expected to continue for a very short time and it might be said that, while it is not definitely known at what pressure naphtha production will cease, the period of naphtha production of these wells will be over in another two or three years at the most. In the meantime, they are drawing on the common energy of the whole field, an energy without which, naphtha recovery will be practically impossible. Entirely apart, therefore, from the question of wastage of gas as a commodity of value, the conservation of that energy is a matter of vital importance to the field as a whole.

Gas and Naphtha Production in the Field.

The total annual production of gas and naphtha in the field to the end of 1932 and the average daily production of gas and naphtha with average daily gas oil ratios for each month during the years 1930, 1931 and 1932 are shown in the two tables following. The records have been supplied by the Petroleum and Natural Gas Division of the Department of Lands and Mines. The average daily production monthly during the last three years is also shown in graphic form in a chart attached hereto and identified as Appendix "D".

Annual production of Natural Gas and of Naphtha in the Turner Valley Field.

	Gas thousand cubic feet.	Naphtha barrels.	Gas oil ratio.
1925	8,760,000	165,717	52.9
1926	8,800,000	211,008	41.8
1927	13,870,000	290,270	47.8
1928	21,320,000	410,623	51.9
1929	61,450,000	908,741	67.6
1930	114,080,000	1,314,039	86.8
1931	169,280,000	1,345,689	126.0
1932	111,080,000	854,116	130.0

AVERAGE DAILY PRODUCTION OF NATURAL GAS AND OF NAPHTHA IN THE TURNER VALLEY FIELD.

	1930.				1931.				1932.			
	Naphtha Bbls.	Gas M.c.f.	G/O Ratio	Number Producing Wells	Naphtha Bbls.	Gas M.c.f.	G/O Ratio	Number Producing Wells	Naphtha Bbls.	Gas M.c.f.	G/O Ratio	Number Producing Wells
January	2646.3	173,220	65	32	5147.6	519,523	101	74	2583.4	378,101	146	88
February	2529.3	172,510	68	32	4901.8	529,440	1 8	78	2571.9	376,954	146	88
March	3201.9	232,000	72	35	4512.5	525,755	116	79	2603	406,980	156	88
April	2768.4	196,610	71	40	4422.7	547 116	124	79	2709.3	436,050	167	88
May	2756.8	180,920	65	44	4370.	580,505	133	83	2406.4	345,267	139	89
June	3357.3	249,200	74	51	4216.1	586,630	139	84	2463.7	327,372	133	90
July	3234.7	248,500	77	55	3196.4	423,796	132	85	2337.2	266,842	114	90
August	3721.5	373,900	100	58	2695.5	368,113	137	85	2212.4	224,245	102	90
September	3951.4	397,310	100	60	2761.5	379,400	136	86	2092.	234,246	112	90
October	4840.	495,945	102	66	2601.7	367,055	141	86	1996.2	218,176	110	90
November	4160.3	483,650	103	69	2672.6	366,444	136	86	2015.3	232,655	115	90
December	5341.3	540,150	101	71	2810.2	381,676	136	87	2070.4	211,715	102	9[illegible]

Results of Test Work Conducted by the Board

The results of the Board's field tests are briefly set out in the following appendices:-

1. Tabulated Statement showing data compiled from field tests and being Appendix "A" to this Report.

2. Isograph pressure map of the field, being Appendix "B" hereto.

3. Chart showing 72 hour closed pressure and rate of naphtha recovery during the ten day test and the gasoline content of tail gas, being Appendix "C".

Analysis of Waste Gas. It was felt desirable by the Board, when the tests were inaugurated, that an analysis of the gas, after leaving the separators - commonly referred to as "tail gas" - should be made during the period of the carrying on of these tests for the purpose of determining its gasoline content. This was done, the result showing that the present method of the separation of the naphtha from the gas adopted in Turner Valley, leaves a large amount of naphtha unrecovered, this amount being included in the residue gas, the greater part of which is burnt, the balance being used in the Gas Company's system. Elimination of this waste by a more efficient method of separation would substantially increase the naphtha production in the field. The loss in the high pressured wells is much less than in the wells where there has been a heavy decline in pressure. In many of the latter wells, this loss amounts to several times the naphtha actually recovered. It is only fair to

say that the Board's figures in this connection include the high volatiles which it may be impossible to utilize but even making allowance for this fact, it is apparent that the present separation methods are decidedly wasteful.

The results of the analysis of tail gas are shown in the tabulated statement, Appendix "A" and the chart comprising Appendix "C".

Area in the Field.

In arriving at any conservation plan, it has been necessary to endeavour to determine the amount of acreage which can be fairly considered as producing or potential producing. This acreage is described in the plan submitted by the Board as acreage on structure.

The boundaries of the area, as determined by the Board, are shown in the accompanying map (Appendix "B".) The Eastern boundary is determined by the Eastern limit of the producing limestone. It has been found from the data obtained in drilling operations, that the limestone is cut off towards the East by a thrust fault which extends in a Northerly and Southerly direction throughout the field. The boundary as drawn represents, to the closest approximation from the data, the Eastern limit of the producing limestone. The wells situated East of this line have failed to encounter the limestone but have encountered the plane of the fault which has been responsible for the removal of the limestone out of reach of possible production. The data used in this determination are on record in the Petroleum and Natural Gas Division of the

Lands and Mines Department, being set out in Appendix "E" hereto attached.

The Western boundary is the boundary between the Belly River and Benton formations. The dips are on the whole fairly steep to the West and the elevation of the surface increases sharply westwards to the Belly River shales. Because of these two facts, the depth at which the limestone would be reached increases rapidly towards the West and the boundary may be taken in the light of our present knowledge, as the probable Western limit of economical drilling. There is attached to this Report, as Appendix "F", the map of the Dominion Department of Mines, on which this boundary is based.

At the South end of the field, the dips in the somewhat limited exposures are sharply southwards. Here, too, the boundary is drawn to represent in the light of present knowledge, a probable southward limit of economical drilling. At the North end, the boundary is drawn approximately one-half mile North of the most Northerly productive well. Wells hitherto drilling North of this boundary line have not encountered productive strata.

It will be noted that the Northern, Western and Southern boundaries are not defined by structural breaks in the formation. It is not improbable that further drilling will give information which will necessitate changes in these boundary lines. The Board feels that the area as defined, should be taken in the first instance and that revision should only come when the data of production are revised as a result of the operation of the field over a period of a year. The acreage of the area delimited by

the Board is 8521.3 acres.

An application was made by Model Oils, Limited to have its acreage withdrawn from the conservation area, on the basis of a submission that Model Well No. 1 was drawing its oil from an independent geological structure. The Board feels that the geological evidence is not sufficiently conclusive to warrant the withdrawal of this acreage from the conservation area. On the basis of the distinctive character of the well, however, both with regard to oil and gas oil ratio, Model Oils, Limited is given special consideration in the proration plan as submitted by the Board.

Findings of the Board.

The Board is required under the terms of the Act, (Sections 15 and 16) to make certain findings, which in so far as it has been possible to do so, are now set out.

(a) Reserves of Gas.

The Board is convinced that reserves of gas in this area or in any part of it, cannot be estimated with mathematical accuracy on the basis of the data obtained during the test work conducted by the Board or by comparisons of well pressures secured by the Department of Lands and Mines in 1931 and those obtained by the Board in 1932. The Board believes, however, that an estimate of 512 billion cubic feet of gas, available above 400 lbs. pressure, as at the end of November, 1932, or a gas flow of 57½ billion cubic feet per 100 lbs. of pressure drop

is a reasonable minimum estimate of the reserves of gas in the field.

This minimum estimate is based upon the estimated gas flows and measured pressure drops recorded in the tests made between July 4th and October 27th last, compiled separately for each of eleven regions in the field, and the average of 24 hour closed pressure of each region as compiled by the weighting of equal pressure areas from the Board's pressure isograph map showing assumed pressure contours as of November 24th, 1932.

The minimum reserves are estimated on the basis of gas available above 400 lbs. pressure per square inch for the reason that this pressure is assumed as being the lowest average pressure at which gas in Turner Valley could be collected, treated and sold without repressuring. There would still be left available in the field, 230 billion cubic feet of gas, a portion of which could be used by repressuring.

The possibilities of variation of any estimates of gas reserves in the area, as made by competent authorities, are well illustrated in the estimates submitted to the Board at the Public Inquiry, and cited hereunder. These estimates tend to confirm the Board's estimate as a minimum.

Doctor Oliver B. Hopkins, a geologist representing the Imperial Oil Company, estimated the reserves at 70 billion cubic feet per 100 lbs of pressure decline, or 600 billion cubic feet down to 400 lbs. pressure, with an additional 280 billion cubic feet down to atmospheric pressure.

Mr. B.F. Hake, representing a large number of independent operators in the field, submitted two estimates, the higher of which indicated reserves of 723 billion cubic feet down to 400 lbs. pressure, with an additional 323 billion cubic feet down to atmospheric pressure. This estimate was based on a gas flow of 80 billion cubic feet per 100 lbs. of pressure decline. Mr. Hake's lower estimate was 593 billion cubic feet down to 400 lbs. pressure, with an additional 390 billion cubic feet down to atmospheric pressure.

Mr. Stanley J. Davies, a geologist representing Mercury Oils, Limited, Miracle Oils, Limited, Mill City Petroleum and the East Crest Oil Company, Limited, estimated reserves at 476 billion cubic feet above 400 lbs. pressure, but qualified his statement with the opinion that this estimate was probably high. It was understood that this estimate was based upon the calculation of reserves by regions.

Mr. S.E. Slipper, geologist for the Canadian Western Natural Gas, Light, Heat and Power Company, Limited, discussed at considerable length the difficulties of estimating reserves with the data available. He had finally decided to base his estimate on an assumed original rock pressure of 2,050 lbs., a present (November, 1932) average rock pressure of 1220 lbs. and a total gas flow to that date of 477 billion cubic feet. These data show a gas flow of 57.4 billion cubic feet per 100 lbs. of pressure decline and indicated gas reserves of 470 billion cubic feet above 400 lbs. pressure and 701 billion cubic feet down to atmospheric pressure. This estimate was

further qualified by evidence that it would be reduced if consideration were given to deviation in certain gases from the general principles of Boyle's law of pressures and volume.

It is apparent that before a reasonably accurate measurement of these gas reserves can be made, the entire field must be put on a metered basis so far as gas production is concerned and closed in pressure tests carefully taken, at least once, if not oftener, each year. A uniform method should be adopted for arriving at an average pressure for the field during the period of each pressure test.

In the estimation of gas reserves, the Board has not considered the question of danger to the field from water, there being no evidence of destructive water encroachment.

(b) The probable lifetime of the field is, of course, dependent on the one hand on the size of the reserves, as to which the Board at present can only make a minimum estimate and, on the other hand, upon the rate at which the gas is drawn from the field. With the necessity of observing the gas flows and closed pressures of the wells for at least a year more, for the purpose of determining more definitely the question of reserves, it is impossible to estimate the length of time that the field will continue to produce. Furthermore, it appears to be the unanimous opinion of the operators, and it is also the opinion of the Board, that no definite plan of conservation should at the present time be effective for a greater period than a year, and that at the end of that year, it should be varied in accordance with the new data then available. While, therefore,

it might be said that conservation at a constant rate such as the Board has recommended later on in this Report, would mean operation of the field for a period of approximately seven years down to a pressure of 400 lbs., it cannot be assumed that the rate of restriction will be uniform over that period but the production will gradually suffer further curtailment from time to time.

(c) The estimate of the immediate and prospective requirements of gas for domestic and industrial use offers little difficulty. The annual consumption of the Canadian Western Natural Gas, Light, Heat and Power Company's system at the present time is approximately seven billion cubic feet. Another billion cubic feet or so is used by Imperial Refineries and a certain amount will be used in the field. An estimated requirement of ten billion cubic feet per year for the next few years would appear reasonable.

(d) Some three years ago, a committee on conservation, representing the Dominion and the Province, went at considerable length into the question of the use of natural gas for industrial purposes. Various uses were suggested to that committee and investigated, such as the manufacture of carbon black, benzol and other products. More recently, Doctor Boomer, of the University of Alberta has carried on in Calgary further large scale research work on the pyrolysis of the Turner Valley gas, for the recovery of light oils and tar. The results have been attractive and estimates of the cost of a commercial unit have been prepared.

The difficulty about the establishment of any industries to utilize gas for purposes such as have been mentioned, is the lack of a market for the product, large enough

to warrant the investment necessary for such an enterprise. It may be said that the amount of gas that any industry would require would not be large, in comparison with the present production, but even so the assurance of a long lifetime for the field would be essential if it were found that such industry was commercially possible.

(e) Methods of effecting conservation are dealt with later on in this Report and certain definite recommendations are made in regard thereto.

(f) The measured value of each area and of gas and oil rights in the field has been dealt with on a comparative basis only. The result of an attempt to arrive at an actual monetary valuation of the different properties in the field would be difficult as well as unsatisfactory, as such values must vary from time to time not only in accordance with prevailing prices of petroleum products but also according to prevailing conditions. Any values arrived at by the Board merely appear expressed in the allowance of gas allotted to each well or property and appear in the plan dealt with later on in this Report.

(g) The total daily gas production which may properly be allowed in the field is discussed in connection with the plan the Board is submitting herewith.

Conservation by pooling.

As already indicated, one of the responsibilities of the Board was to endeavour to promote voluntary pooling. Pooling, however, can only be carried forward systematically if accurate data are available of the productive capacity of the individual wells and of the potential production of undrained acreage. Naturally, before any pooling negotiations

were undertaken, the operators desired that the data resulting from the Board's tests should be available.

Apart from this, any unitized operation of the field, whether on a voluntary or compulsory basis, appeared to present two major difficulties. The first of these, encountered prior to the advent of the Board, was that no agreement could be reached between the operators as to the method of representation of the various interests on the managing board. The second difficulty related to the measurement of value of the various properties. In the study of the data which have been accumulated from the field tests, the Board arrived at the conclusion that it would be unwise to endeavour to establish values on individual properties without continuous operation of the field under recording meters, over a period of at least one year. The main problem is that of potential reserves in undrilled acreage on which, at best, under the data now available, only a minimum estimate can be placed.

A study of the data secured by the Board during tests, presents some interesting sidelights on the importance of pooling of interests in the field and the conservation of gas energy that might thereby be effected through the closing down of low pressure, high gas oil ratio wells and the general benefits that would accrue to the field as a whole.

The results of the ten day tests on 84 wells, showing gas and naphtha production, operating at 66-2/3% of closed in rock pressures, are given with other data in appendix "A" to this Report.

An analysis of these records, including as production all naphtha obtained by blowing, shows that 23 wells, each having gas oil ratios under 125 M.c.f., were capable of producing at that back pressure, 2,295 barrels of naphtha with

149,561 M.c.f. of gas, or at a gas oil ratio of 65 M.c.f., while 61 wells, each having gas oil ratios higher than 125 M.c.f., operating under the same percentage of back pressures, produced only 856.8 barrels of oil with 248,041 M.c.f. of gas, or at a gas oil ratio of 289 M.c.f.

The figures are tabulated hereunder, showing totals by groups of wells.

	Ten day test on 61 high gas oil ratio wells.		Ten day test on 23 low gas oil ratio wells.			
	Gas Prod'n. M.c.f.	Naphtha Barrels	Gas Prod'n. M.c.f.	Naphtha Barrels.		Totals
Independent	87,604	333.6	69,085	969.8	156689	1303.4
Imperial Subsidiary...	103,080	384.4	52,045	590.5	155125	974.9
Imperial Contract.....	57,357	138.8	28,431	734.7	85788	873.5
Imperial ..	160,437	523.2	80,476	1325.2	240,913	1848.4
Total	248,041	856.8	149,561	2295.0	397,602	3151.8
	Gas Oil Ratio	289	Gas Oil Ratio	65	Gas Oil Ratio	126

The daily average production of the field in the month of December, as reported by the Department of Lands and Mines, was 2070.4 barrels of naphtha, produced with 211,715 M.c.f., or at a gas oil ratio of 102 M.c.f. The 23 wells, comprising the high pressure low gas oil ratio group above referred to, contributed to December production to the extent of 1563 barrels, obtained with 75,720 M.c.f. of gas, or at a gas oil ratio of 48 M.c.f. As the wells are not metered and there may be a disposition to understate gas production, these gas production figures may be open to question. The correction of any error

in this direction would merely strengthen the basis for the following conclusion.

It is apparent, therefore, that as shown by the ten day tests, 23 wells, when operated at 66-2/3% closed in rock pressure, were capable of producing more naphtha from 150,000 M.c.f. than was produced from the entire field in December from over 211,000 M.c.f. It would thus seem to be a reasonable deduction that really effective measures of conservation in the field should be brought about by the complete closing in of wells when these have reached a high gas oil ratio stage.

While some form of agreement, pooling or unitized operation of the field involving the closing down of wells having high gas oil ratios would undoubtedly result in the most efficient form of operation and conservation of gas energy, the Board would hesitate at the present time, to recommend that it be brought about by compulsion.

Any plan of conservation that is attempted to be based upon relative operating efficiencies of the various wells in the field, particularly in so far as naphtha recovery is concerned, cannot but appear to bear harshly upon those wells with depleted pressures and high gas oil ratios. On the other hand, to adopt any scheme which does not stress efficient operation means the penalizing of efficient wells and must diminish naphtha production, for it must encourage the heavy use of gas energy to recover small amounts of naphtha.

The tendency on the part of the operators of these low pressure wells is to continue operations regardless of the

effect their method of operation may have upon the field as a whole. Without any form of limitation of production, they would probably continue to operate their wells until the pressure had decreased to such an extent that the lifting power for the naphtha was gone. There are one or two cases at present where the return from operation is barely sufficient to pay the men operating the separators.

The operators of some of the more efficient wells have pointed out that these low pressure wells have, to a large extent, obtained their possible naphtha production and that the stage of wasteful operation which has now been reached must result in penalizing those operators who, warned by the results of the inefficient operation of other wells, have endeavoured to operate efficiently from the outset.

It is hoped that some measure of pooling may be accomplished under the Board's proration plan as that appears to offer some solution of the difficulties that must be encountered by those companies operating low pressured wells.

Again, in the operation of these inefficient wells, the adoption, if feasible, of a less wasteful method of blowing the wells may afford some solution. In many cases, it is usual at present to obtain naphtha production by blowing, but between blowing, the gas flow is continued with the result of an excessive use of gas for the amount of naphtha recovered.

It is also probable that through the tubing of some of these wells, considerably greater naphtha may be recovered with considerably less gas consumption. No proper trial of this practice has been attempted in Turner Valley, although it has long been in use in other fields.

Conservation by proration.

In the place of any voluntary pooling which, at the present time does not seem feasible, if the whole field is to be covered by such pooling, and in the place of any compulsory unitized operation of the field, the Board believes that conservation at the present time can be more readily effected through putting into effect a plan of proration of gas to be allowed to be produced in the whole field.

At the public hearing, Mr. B.F. Hake, representing a number of the smaller companies, submitted a plan of proration, based upon a daily allowance for the field of 300 million cubic feet of gas. Under this plan each well was to be required to produce under a back pressure, not less than a certain percentage of its recent twenty-four hour closed in pressure, this percentage to be a uniform one throughout the field. Actual back pressures to be carried by each well were to be revised annually in the light of future observation of closed in pressures and when practicable, bottom hole pressures should be substituted for closed in pressures. Each operator was to be permitted to blow his well or wells under certain restrictions and, where the system of proration suggested appeared to unduly penalize an operator, special consideration should be given to his well or wells. All restriction as to export of natural gas from the Province was to be removed and either the common purchaser principle with respect to natural gas was to be brought into effect or compensation paid to the operators by the Gas Company. Finally, a revision of the taxes on mineral rights and oil production was suggested.

In regard to this plan, it may be said that it is based upon Mr. Hoke's estimate of gas reserves, which estimate very considerably exceeded those of any other witnesses at the inquiry. Proration on the basis suggested means the withdrawal of 110 billion cubic feet of gas a year at the outset. In the Board's opinion, the data available do not warrant the adoption at the present time of conservation on as generous a scale as suggested. It may be said also, that such proration allowance would probably result in the production of naphtha beyond the market needs, while it is more than doubtful whether some at least of the companies represented by Mr. Hoke, would be placed in any better, if as good a position, as they are now in under the proration now in effect.

There are two essential elements which should be considered in any proration plan. The first is that it should permit as great a measure of flexibility in operation as possible so that the operators may have within the limits of the conservation programme, the fullest freedom to operate as may seem to their best advantage. The second is that the plan should put as great a premium as possible upon efficient operation within the limits of the conservation proposed.

The Board has, with the assistance of its Advisory Engineer, worked out a plan of gas proration in the field, as set out in detail in Appendix "G" to this Report. The gas allowance to each operator or owner of gas and oil rights within the area, is based in part upon acreage on structure, weighted by average pressures and in part on actual efficient naphtha production as determined by test.

Prior to the public inquiry, a draft of substantially the same plan was sent out by the Board to the various parties interested and the fullest discussion of the plan was invited at that inquiry. It may be said that there appeared to be no objection to the principle of proration and the principles of the plan itself were not subject to any great criticism, although it is only fair to say that Mr. Hake, in presenting his own plan, already referred to, may be considered as disagreeing.

In the operation of this plan, a gas quota assigned to a particular holding, may be used on any well or wells in that holding and under any method of production which may be to the greatest benefit to the operator. He may operate at any pressure which he may deem advisable. He may conserve the gas allowance at certain periods of the year in order to have it available in greater amount at such times as the demand for naphtha is greatest, always provided that no more gas is allowed to escape during the year than would be permitted under the quota. If he cannot use the quota which has been assigned to his holding, under the plan, whether because there is no well on the holding or because production cannot efficiently be obtained from the well or wells which exist, he may make arrangements to transfer the quota by sale or otherwise in order that it may be used to increase naphtha production elsewhere within the Turner Valley area.' The only limitation to the transference of quotas would be that differences of pressures on adjoining wells on neighbouring properties should not be permitted to the extent that undue depletion of the reserves on any property would occur, because of the much lower back pressure at which the well or wells on adjoining properties

were operating. It would be the responsibility of the Supervising Engineer to see that this safeguard be maintained.

The plan promotes efficient operation of the field because it is to the advantage of the operator to obtain the greatest amount of naphtha possible from the gas which has been allowed him. The value of his production is mainly in naphtha and only secondarily in gas, even if he obtains a market for the gas. The gas quota will, therefore, be used in such a way as to obtain the greatest amount of naphtha under the conditions which prevail in any well or group of wells in a holding. If this quota is transferred to another holding, the operator who has the lowest gas oil ratio can offer the best terms for the quota to be transferred because it is of most value. Transfers might be expected, therefore, to take place in the areas of efficient production in the field.

There is also a premium on efficiency of operation in the structure of the plan itself. As will be noticed by an examination of the details of the plan and the accompanying explanation, the proration quota is made up in part from the naphtha production of the wells and in part from the acreage potential, that is, the product of acreage and its average available pressure. The proportional weight given to naphtha production, as compared to acreage potential, is approximately as 30 to 70. Under this plan, the more efficient the production, the lower is the gas oil ratio, in other words, the larger is the proportional quota. The operator who is producing under the lowest gas oil ratio possible for his wells obtains a higher gas quota in subsequent revisions, than the operator who obtains the same amount of naphtha at a greater expenditure of gas because of the fact that the acreage potential is main-

tained at a higher level under efficient production methods when gas is not unduly wasted. The structure of the plan itself, therefore, and the effect of the revisions which will take place from time to time, as further data are established, together tend to promote the highest efficiency of operation in the field, short of establishing hard and fast rules for the individual operator.

It might also be pointed out that in future revisions of the plan on the basis of revised data respecting acreage, average pressures and naphtha production, automatic curtailment of the total gas allotment to the field would be secured by maintaining in such revisions, substantially the same unit quotas as are now set out in the plan submitted, namely, 19.11 thousand cubic feet per barrel of naphtha produced, 26.291 cubic feet per average pressure acre for drilled acreage and 13.145 cubic feet per average pressure acre for undrilled acreage.

It will be seen by a reference to the plan itself that while a total daily gas allowance of 200 million cubic feet is contemplated, an amount of 10 million cubic feet has been set aside out of that amount, to meet any proration allowances for naphtha production that may require to be given in the case of new wells coming in, and also to cover certain allowances that have been or may have to be given to two very low gas oil ratio wells as well as to cover any readjustments that may have to be made in the case of producing wells.

Compensation.

One of the purposes of the Public Inquiry provided for in the Act was the ascertaining by the Board of the net detriment suffered and benefits derived by any person or group of persons through conservation of gas. No evidence along these lines was offered at the hearing, it being apparently the unanimous opinion of the operators that the question of compensation could not be intelligently discussed or dealt with until any conservation plan that might be adopted, should be in effect for at least a year. It is quite apparent, therefore, that the question of compensation should be left entirely open and be determined later on by some body selected for that purpose.

Recommendations.

In conclusion, the Board begs to recommend as follows:-

1. Removal of restriction of drilling. That in view of the fact that a definite restriction of the total gas production in the field is recommended under the plan submitted by the Board and that the drilling of wells will not materially affect the total allotment of gas for the field, any restrictions that may be now in effect as to drilling into the limestone in Turner Valley, be rescinded.

2. Installation of meters and pressure gauges. That Sections 31 and 33 of the regulations respecting drilling and production operations of oil and natural gas wells (Order in Council

769/31), dealing respectively with the taking of closed in pressures and of the measuring of gas production by meter, be strictly enforced in the field, in order that more accurate information may be available in the future on which to base estimates of gas reserves, and on the basis of which revision may be made from time to time of the gas proration plan recommended in the next section.

3. Gas Proration Plan.

(a) That as soon as it may be found convenient, the present restricted production of gas in the area under the Board's Order No. 20, be replaced by a gas proration plan in which a gas production allotment is made to each and every owner of oil and gas lands lying within the assumed boundaries of the productive gas horizon in the Turner Valley area, as shown on the Board's pressure isograph map and Appendix "B", based upon acreage, estimated average pressures and efficient naphtha production in the manner shown in detail in the plan, being Appendix "G" attached hereto, and that the proration of gas production be administered by such authority as the Legislature may determine.

(b) That until a revision of the plan is made after the first year of operation, any additional allotment arising out of the bringing into production of new wells or for any other reason, shall be met out of any available allotment not being used and, if necessary, by an increase in the total daily allotment. The allotments as set out in the plan should be effective for one year and be revised thereafter at such periods as may be found expedient, on the basis of revised data respecting acreage, average pressures and naphtha production, and

having regard to the possible desirability of a further reduction in the total daily allotment.

(c) That in the enforcement of this plan, sufficient flexibility be allowed to permit of the most efficient use of gas quotas. To this end, operators should not be arbitrarily restricted to the fixed daily quota but should be permitted to accumulate such quotas for any type of more efficient operation. Similarly, transfers of quotas from one owner to another, by sale or lease of gas and oil rights should be facilitated in order that the owners of lands who have not drilled, may find a market for their holdings. All such flexibility, however, shall be subject to the proviso set out in the next subsection.

(d) That in the operation of this plan, accumulations of gas quotas shall not be used on any one well or any group of wells so as to excessively drain any particular area.

(e) That in preparing future revisions of this plan, the recovery of natural gas gasoline from the gas from any well be included with naphtha production for the purpose of determining gas allotments.

4. Compensation. That the question of the determination of compensation to individual oil or gas operators in the area be deferred for consideration by such body as the Legislature may appoint after the proration plan herein recommended, has been in operation for the time indicated.

5. Further Study of Records.

(a) That all the records and information collected by the Board be referred to the Petroleum and Natural Gas Division of the Department of Lands and Mines or such other authority as may be determined, for further detailed analytical study

when the additional data respecting changing pressures and operating conditions in the field during the coming year are obtainable, so that the fullest possible information may be available for the future determination of gas reserves and of gas conservation policy.

(b) It is further recommended that the results of these studies be brought to the attention of the operators with a view to assisting them in developing a scheme of voluntary pooling or unitized operation.

In submitting this Report, the Board desires to express its high appreciation of the loyalty and efficiency of the various members of its office and field staff. Much of the work devolving on them has been both arduous and difficult, but their work has fully justified the Board in the selection of the personnel of its staff.

Dated at Edmonton, this twenty-second day of February, A.D., 1933.

Respectfully submitted,

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